tify he can balance steam turbines until I watch him do it correctly several times. The most significant parts of a certification program are to document the name of the employee, date and type of training, and how the employee proved that he understood the material or performed the task.

Passing an exam can prove an employee understands a subject. However, if the training involves a skill, the employee must demonstrate that he has the skill and ability to perform the task. For example, if he was taught how to calibrate a monitor, then the technician should show that he can. The performance is then documented.

Who can establish a program?

A certification program may be established by a plant to ensure that individual employees meet standards of performance outlined in specific job classifications. The main purpose of the program is to prevent an unqualified employee from adversely affecting people, the plant or the process. People are often under the misconception that a certification program must be sponsored by a governmental entity or other organized group. This is probably because state governments have established procedures to license engineers, doctors, lawyers and accountants, as assurance that the public is protected. In the field of vibration analysis and machinery management, no governmental organization has established standards of performance. They are the responsibility of each plant.

Bently Nevada can help you establish a vibration analysis and machinery management certification program at your facility.

Remember, the most important element is documentation to demonstrate that established standards have been met.

Our personnel will come to your facility, so we can understand the job descriptions and standards of performance you have developed. We will evaluate your employees' performance against your established standards, certify that they meet them or recommend and perform the training they need. ■

Differential Expansion

An essential measurement in a Turbine Supervisory System

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Turbine components that expand and contract with changes in temperature can result in rubs between rotating and stationary parts, for example, turbine blades and case, diaphragm or stationary blades. The thermal expansion is due to the high temperature steam as it is added to, and removed from, the turbine system. It is typically greatest during machine startup and shutdown. It is a problem because the turbine components expand and contract at different rates which results in a differential expansion.

The most critical differential expansion is between the rotor and the machine case, because it can result in damage to the blades, seals and diaphragms. During startups, as the turbine warms, the rotor expands faster than the case, causing a *Rotor Long* condition. During shutdowns, or when cooler or wet steam is in the steam path, the rotor cools and contracts faster than the case, causing a *Rotor Short* condition.

Because it is so critical, the differential expansion of the rotor relative to the case is an essential part of a Turbine Supervisory Instrumentation (TSI) System.

Specifying a differential expansion measurement

Differential expansion is typically measured at a point on the machine train where axial clearances are most critical. On many machines, it is measured at two or three different locations, usually at the ends of the machine opposite from where each turbine case is anchored (keyed to the foundation). These locations are typically some distance from the thrust bearing, which is used as a common reference point to maintain axial alignment between the machine's rotating and stationary components.

When retrofitting or upgrading a differential expansion system, certain machine information is required to help you select the correct monitor and transducer system:

- The determination of the differential expansion range.
  This information is typically derived from the actual machine clearance data (i.e. rotating-to-stationary blade clearance data). This information is necessary for selecting the proper transducer and the monitor range. Additional sources of this information include the Original Equipment Manufacturer (OEM) instruction manuals, existing differential expansion monitors and chart recorders, and historical machine clearance data.
- The number of locations where differential expansion will be monitored.
  For example: "The machine requires high-pressure turbine and low-pressure turbine differential expansion monitoring."
- The types and dimensions of the probe target areas.

For example: "The low pressure rotor has a ramped differential expansion collar between the low pressure turbine and the generator. The ramp angles are 14°, and the probe target areas are 5 inches in length."

Transducer selection

Differential expansion transducers are mounted on the machine case and observe the rotor (Figure 1). Proximity transducers are preferred; typically, due to the machine growth ranges, a 25 mm, 35 mm or 50 mm transducer system is used.

25 mm and 35 mm transducer systems

The 25 mm and 35 mm transducer systems provide a 12.7 mm (500 mil) linear range. The 25 mm transducer system requires 51 mm (2.00 inches) of unobstructed target. The 35 mm transducer requires a minimum of 57 mm (2.25 inches) of unobstructed target. Refer to Table 1 and Figure 2.

50 mm transducer system

The 50 mm transducer system offers a 25.4 mm (1000 mil) linear range. This system requires a minimum of 102 mm (4.00 inches) of unobstructed target. See Table 1 and Figure 2.

When selecting any transducer, the temperature and the environment at the mounting location are very important. The rotor material or the material the transducer observes should also be identified, to ensure proper calibration.

Transducer	Minimum target area
25 mm	51 mm (2.00 inches)
35 mm	57 mm (2.25 inches)
50 mm	102 mm (4.00 inches)

Table 1

Monitor selection

Three types of Differential Expansion monitors are available.

- Dual Differential Expansion
- Complementary Input Differential Expansion
- Ramp Differential Expansion

Dual Differential Expansion

This monitor requires two probes that observe one side of a collar on the rotor (Figure 3). With 25 mm or 35 mm transducers as input, the differential expansion measurement range is up to 12.7 mm (500 mils). With 50 mm transducers, its range is up to 25.4 mm (1000 mils). Each monitor has two independent channels.

Complementary Input Differential Expansion

This monitor combines the ranges of two transducers, increasing the total system range. Two probes are configured

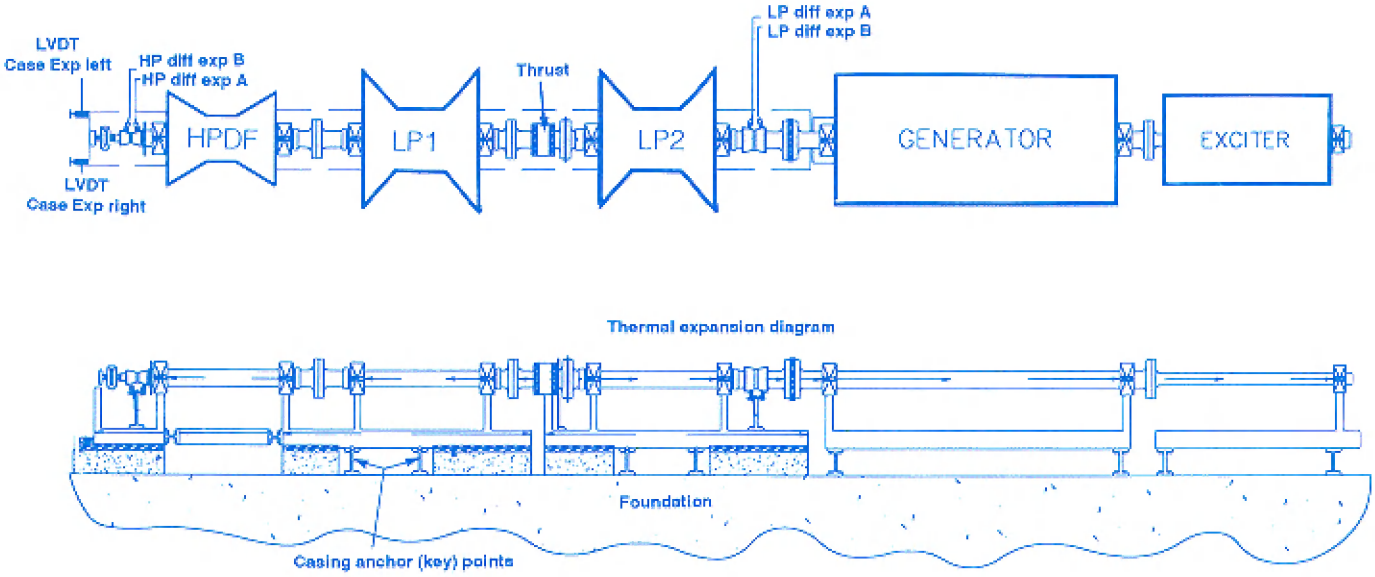

Figure 1
Machine train diagram showing location of differential expansion transducers

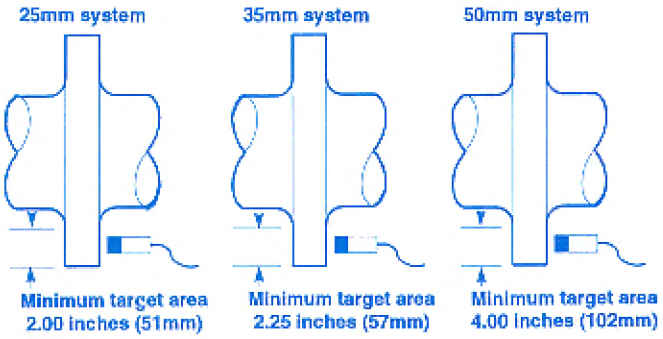

Figure 2
Transducer Selection

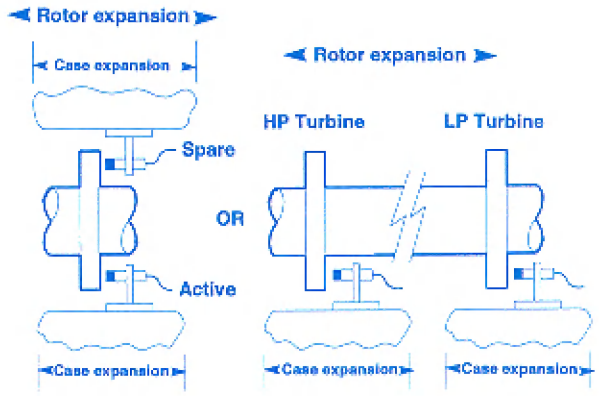

Figure 3
Dual Differential Expansion

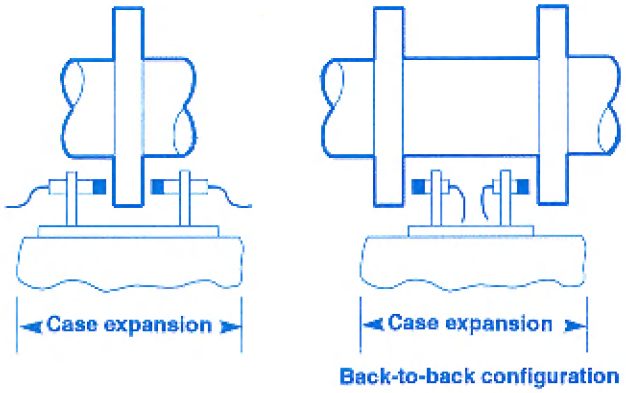

Figure 4
Complementary Input Differential Expansion

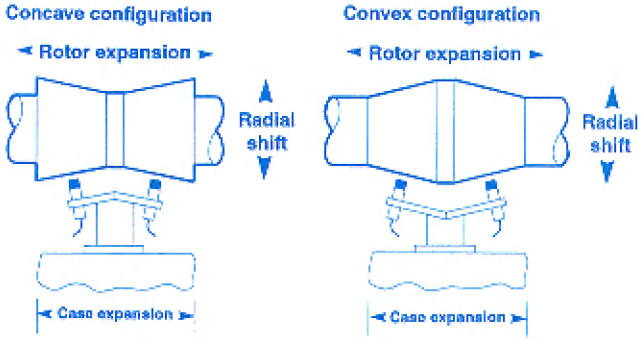

Figure 5
Ramp Differential Expansion

to observe opposite sides of a collar on the rotor, or are configured back to back (Figure 4). With 25 mm or 35 mm transducers as input, the range is up to 25.4 mm (1000 mils). Using 50 mm transducers, its range is up to 50.8 mm (2000 mils).

Ramp Differential Expansion

This monitor uses two transducers which view either a convex or concave ramped collar on the shaft. The differential expansion range depends on the angle of the ramp and the transducer type. The probes in this system, because they are not in a true axial plane, are susceptible to radial shifting of the rotor. The ramp differential monitor accepts the signals of both probes, compares them to each other and cancels out the radial shift motion. The resultant reading is differential expansion (axial movement).

Conclusion

For overall machinery monitoring, turbine case expansion should also be monitored. Case expansion measures the axial growth of the machine case, typically the end of the case opposite its anchor point. When both differential expansion and case expansion are continuously monitored, operators have the vital information needed to evaluate the clearances between the machine's rotating and stationary elements and distortion of the case due to a cocked or skewed case.

Differential expansion is an important measurement during the startup and shutdown of steam turbine generators. Large differences in thermal growth can cause the rotating and nonrotating elements of a turbine to come in contact with each other, possibly causing extensive machine damage. Accurately monitoring differential expansion permits operators to prevent this potentially hazardous and costly situation.

Bently Nevada can help you with your rotating machinery and system installation needs. We offer a complete range of services, from technical consulting to complete design and installation services. Contact your nearest Bently Nevada Sales Office for assistance. ■